Hydropower and Dams
Climate Change Resilience and Adaption

Professor Emeritus Ånund Killingtveit
Norwegian University of Science and Technology, NTNU

Mekong+
New Frontiers in Sustainable Hydropower Development
Hydropower Sustainability Forum
Oslo, Norway 4-6 September 2017

CEDREN
Centre for Environmental Design of Renewable Energy

CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

Dams can be sustainable – some examples

Lake Homs Dam in Syria is claimed to be the oldest dam in the world still in use.

Built 1300 BC during the reign of Egyptian Pharaoh Seti

Still supplies water to the city of Homs

3300 years in service!

Other very old dams still in use:

Proserpina Dam (Spain)	100-200 AD
Cornalvo Dam (Spain)	100-200 AD
Kaerumataike Dam (Japan)	162 AD
Kallanai Dam (India)	200 AD

…

http://www.water-technology.net/features/feature-the-worlds-oldest-dams-still-in-use/

Reservoirs – why do we need them at all?

- Stable water supply is vital for many human needs
  - for direct water consumption (drinking hygiene, …)
  - for food production (irrigation, livestock,…)
  - for industry (process water, cooling, products, …)
  - for energy (hydropower, thermal power, …)
  - for the environment (recreation, tourism, nature, …)
- Water inflow from nature is usually highly variable
- Main challenge: Maintaining security of supply
- Storage is the key to balance supply and demand
- Reservoirs are needed for flexibility and security

Three megatrends - impacting need for reservoirs

Population growth

- Increasing demand for water, food & energy
- Utilizing higher share of available water resources

➔ Need for more reservoir capacity

Climate change

- More or less water
- More variable supply (inflow)
- More floods (?)

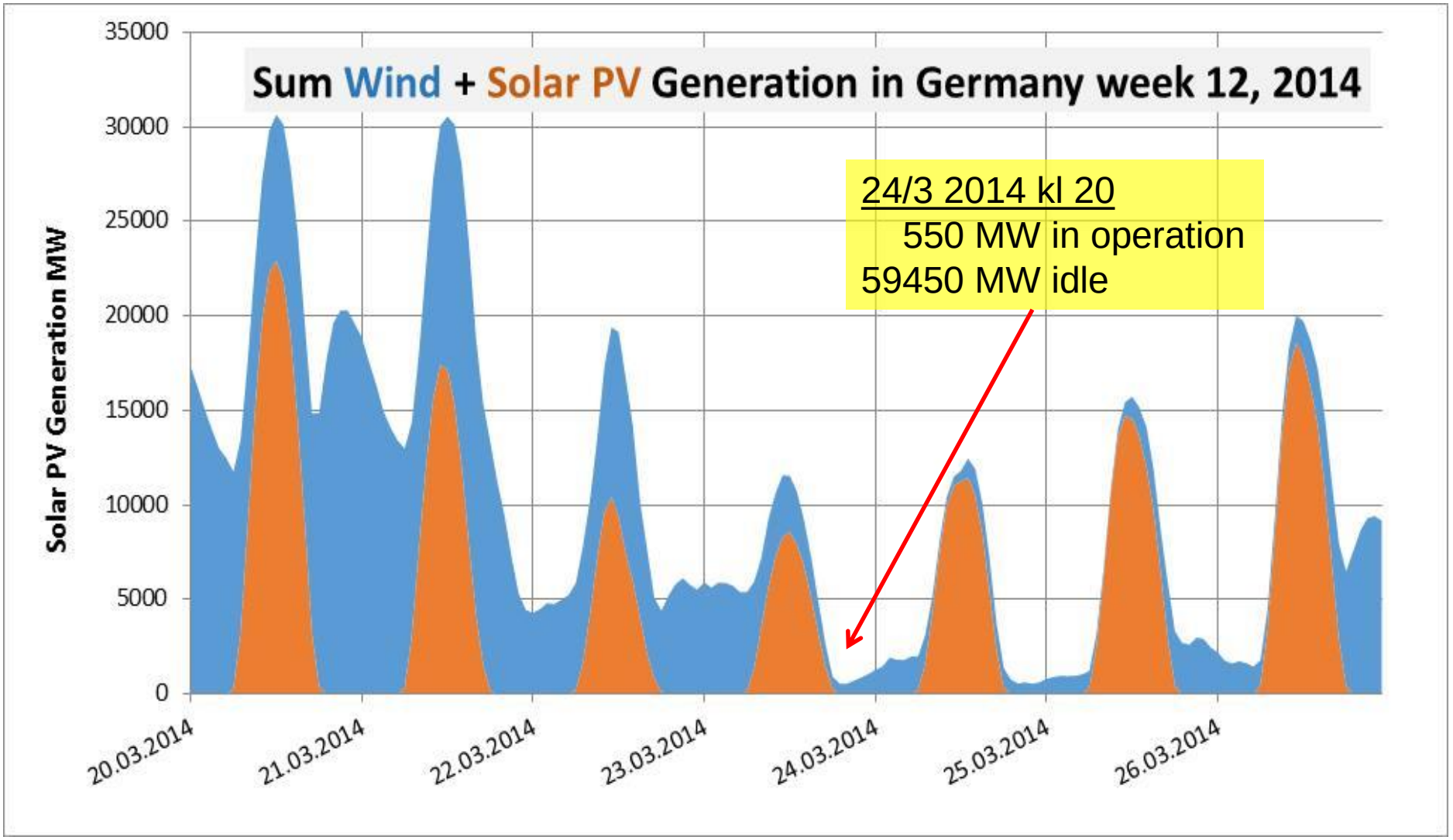
➔ Need for more reservoir capacity

Transition to a renewable energy system

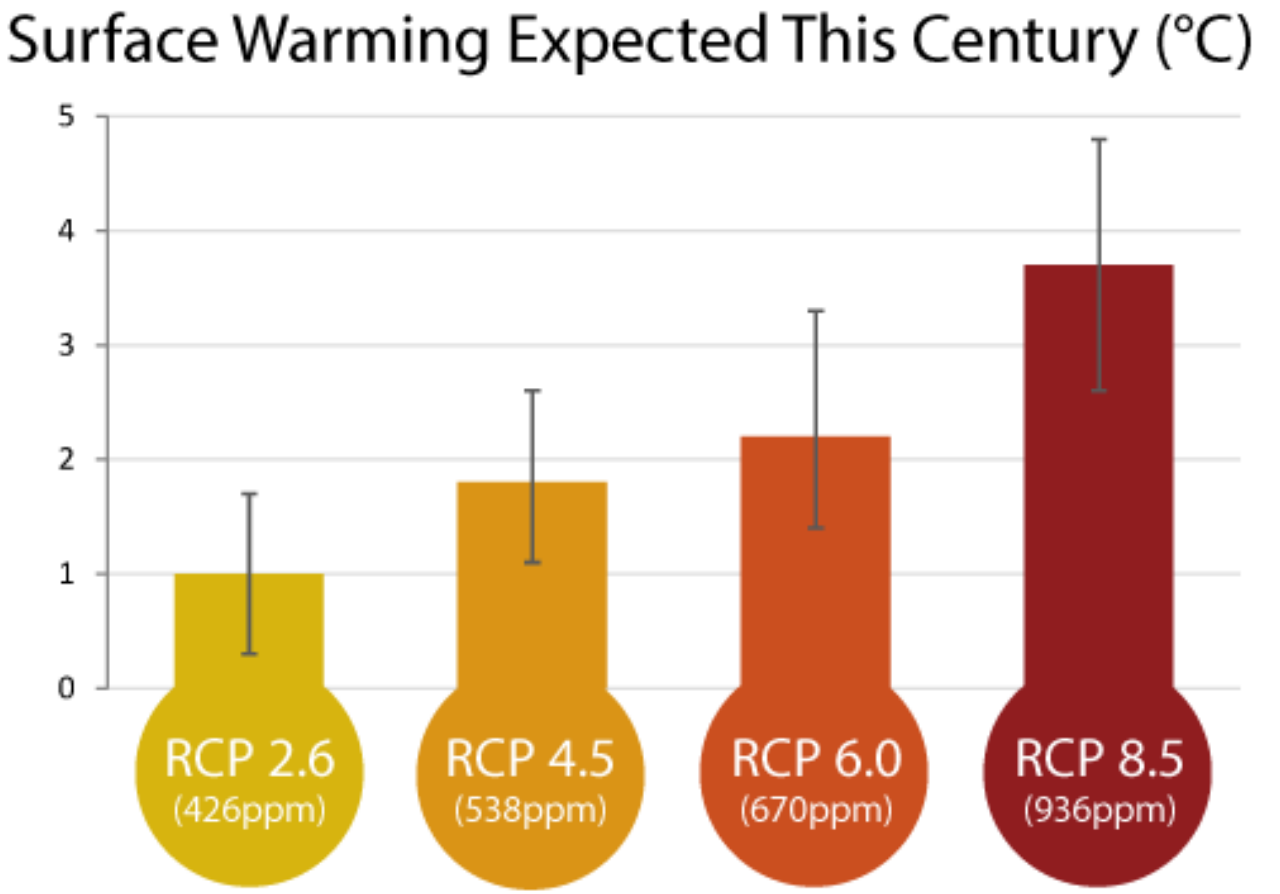
- More hydropower (energy)
- More storage needed for balancing and grid services

➔ Need for more reservoir capacity

Wind + Solar energy in Germany week 13 2014
Capacity 30 000 MW Wind + 30 000 MW PV



Climate change scenarios - depends on GHG concentrations



Note: Each Representative Concentration Pathway (RCP) is numbered according to its total radiative forcing in 2100 relative to 1750 in W/m2. For reference the atmospheric concentration of carbon dioxide expected for each pathway in 2100 is shown. Warming is that expected from the period 1986–2005 to 2081-2100.

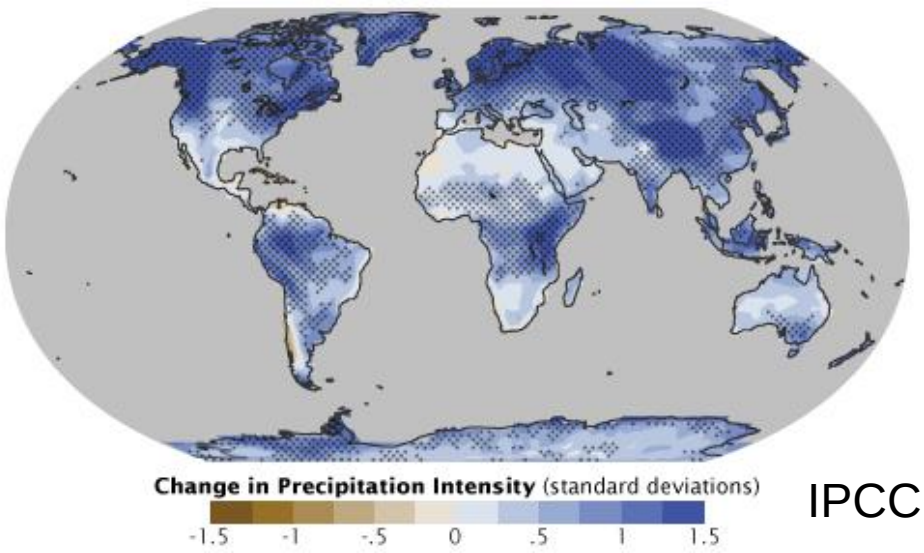
Source: Summary for Policymakers AR5 WG1 IPCC shrinkthatfootprint.com

Climate change (CC) ➔ More variable climate?

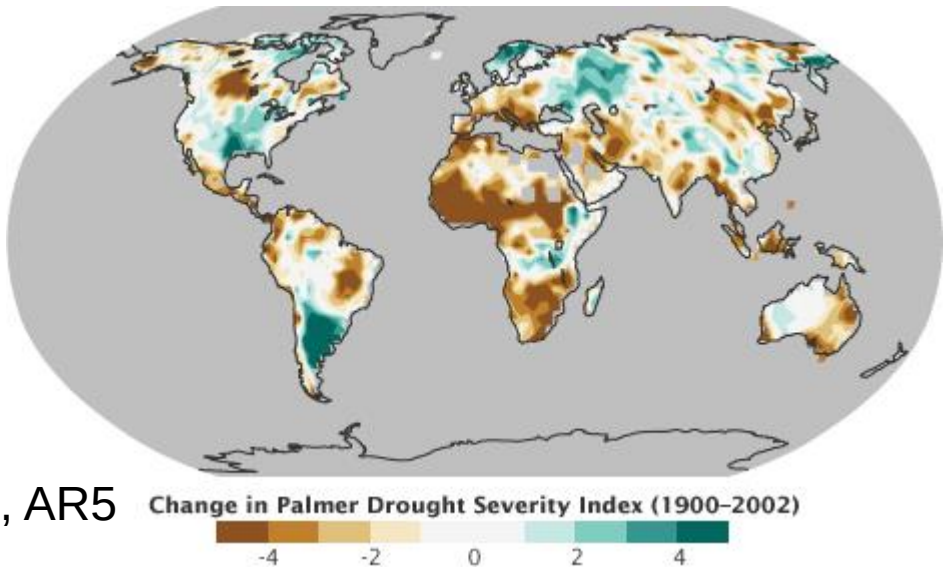
"*The science community now generally agrees that the Earth's climate is undergoing changes in response to natural variability, including solar variability, and increasing concentrations of greenhouse gases and aerosols*.

…

These changes may profoundly affect atmospheric water vapor concentrations, clouds, precipitation patterns, and runoff and stream flow patterns" (NASA Earth Observatory, 2017)



IPCC, AR5



Possible Impacts of CC on the Hydropower system

Direct impacts:

More/less water runoff may increase/decrease generation potential

Changes in seasonal distribution of runoff

Reservoir sedimentation may decrease storage capacity

More extreme floods may be a threat to dams/hydraulic structures

Indirect impacts:

Change in consumption/Market structure

Composition of power system (more wind/solar, less thermal/nuclear)

New environmental restrictions (more flow, reduced peaking, ..)

Hydropower - Adapting to CC-Impacts

Climate is changing – some changes cannot be avoided

There will be significant impacts – mostly negative

We need to adapt in order to minimize consequences

Reservoirs are needed – but also controversial

<u>During 1990's a negative view developed:</u>

- Dams are evil
- Dams are not needed
- Dams should be removed
- …

<u>The truth is different (and now recognized):</u>

- Dams are good (but not all)
- Dams are needed
- More dams needs to be built
- …

<u>But - water resources are still threatened</u>

- By over-consumption
- By poor management
- By climate change
- …

More reservoirs will be needed (and built) in the future

New dams must be built to be:

- Economically efficient
- Socially desireable
- Environmentally acceptable
- …

Important to create social acceptance

- Why new dams are needed
- Benefits > negative impacts
- Those who pay the cost must benefit
- Use IHA Sustainability guidelines
- …

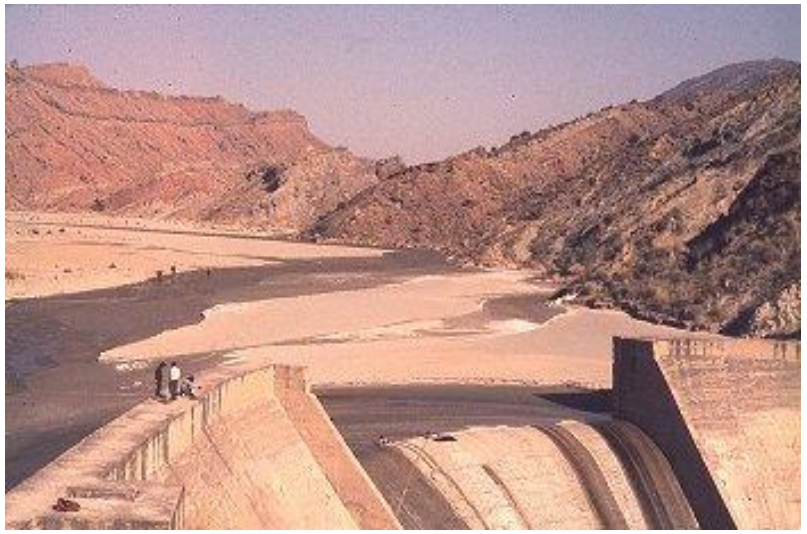
Prepare for future climate change

- Designed to meet future climate
- Easy to adapt if/when needed
- Maximize benefit - multi-purpose use

Some important challenges for dams/reservoirs

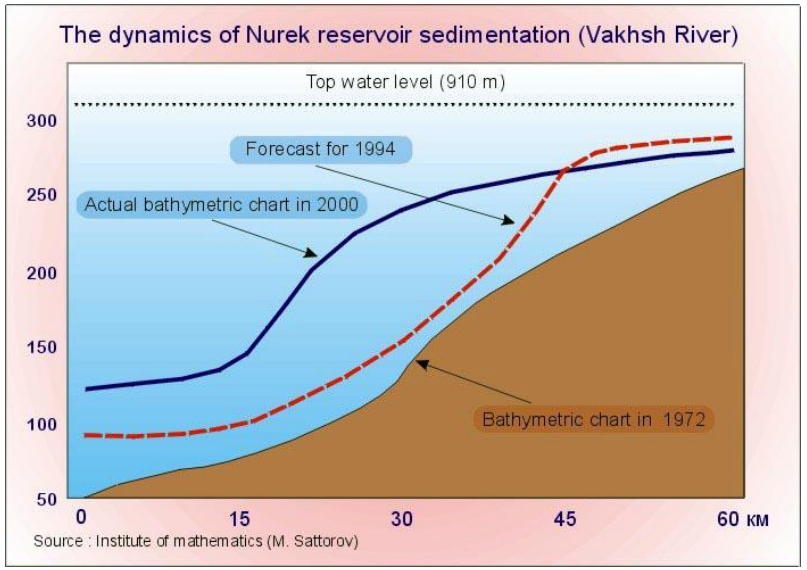
Reservoir sedimentation:

- Changes in land-use
- Climate change
- …



Social/political acceptance

- Realize why new dams are needed
- Environmental design - Sustainability
- Change the public view by facts
- …



GHG-emission and Water loss

- GHG-emissions could be an issue
- Water consumption, maybe an issue?
- Scientific facts about both is needed